Towards Malaria Control In Nigeria: Review Of Multiple Aetiological Factors

By

Chika N. Onwasigwe

Department of Community Medicine, College of Medicine, University of Nigeria, Enugu Campus

SUMMARY

Malaria is a principal cause of morbidity and mortality in the very young children and pregnant women in sub-Saharan Africa. Although *Plasmodium falciparum*, the most dangerous of the four human malaria parasites, is responsible for infections in the area, other aetiological factors exert a lot of influence on occurrence and transmission of malaria. For malaria to be effectively controlled and prevented, such factors which include environmental, host, vector and parasite factors must be attacked through a multi-pronged approach, in line with the strategies of the Roll Back Malaria initiative. This review highlights the various aetiological factors of malaria, and suggests ways of combating the infection in Nigeria.

Key Words: *Malaria, aetiological factors, Roll Back Malaria initiative, prevention and control*

INTRODUCTION

Malaria, a life-threatening parasitic disease, is found in about 100 countries or territories in the world, almost half of which are in Africa, south of the Sahara[1]. Approximately 40% of the world's population, mostly those living in the poorest countries, are at risk of malaria. The disease was formerly more widespread but has been successfully eliminated from many temperate countries during the mid 20th century. Presently, malaria is found throughout the tropical and sub-tropical regions of the world, and is responsible for more than 300 million acute illnesses and at least one million deaths annually[1,2]. Africa bears an overwhelming proportion of the malaria burden. Ninety percent of deaths from malaria occur in Africa, south of the Sahara, mostly among young children. Malaria kills an African child every 30 seconds, and those that survived an episode of severe malaria may suffer from learning impairments or brain damage[3]. Malaria is a major cause of anaemia in pregnancy, perinatal mortality and low birth weight[4,5]. It is also a leading cause of under-five mortality and constitutes about 10% of disease burden in Africa.

Most malaria infections in sub-Saharan Africa are caused by *Plasmodium falciparum*, the most severe and life threatening form of the disease. Apart from the parasite, there are other known aetiological or risk factors that must be present for malaria to occur and be effectively transmitted. The environmental, host, vector and parasite factors, determine the epidemiology of malaria, i.e. the cause, distribution, determinants and deterrents of the disease. These factors must be taken into cognisance before the Roll Back Malaria (RBM) initiative can achieve its aims and objectives.

The sub-Saharan region is habitat to the most efficient and consequently the most deadly species of mosquitoes that transmit the disease, notably the female *Anopheles gambiae*. Apart from the bite of the mosquito, malaria may also be induced by intramuscular or intravenous injection of blood or plasma, as occurs during blood transfusion and exchange of needles by drug addicts[6,7]. Congenital infection of the newborn from an infected mother may also occur, but this is rare. Most countries in the region lack the necessary infrastructures and resources to mount sustainable campaigns against malaria, and so did not benefit from historical attempts to eradicate malaria in the

Correspondence Address:
Dr. (Mrs.) C. N. Onwasigwe, Department of Community Medicine, College of Medicine, University of Nigeria Teaching Hospital, Enugu. ***E-mail:*** *chikaonwasigwe@yahoo.com*
Accepted for Publication: 10th May 2004

1950s. In more recent times, renewed efforts have been commenced to control this scourge in the affected areas.

Roll Back Malaria is a global partnership initiated by WHO, UNDP, UNICEF and the World Bank in 1998, as a result of the incessant malaria problem in the less developed countries of the world[8,9]. Unlike earlier initiatives, Roll Back Malaria seeks to work with affected communities, governments, other development agencies, non-governmental organizations, and private sector companies to reduce the human and socio-economic costs of malaria. The general objective of the initiative is to significantly reduce the global burden of malaria by half by the year 2010, through interventions adapted to local needs and by reinforcement of the health sector. Efforts are directed at giving prompt access to effective and affordable treatment; encouraging the use of insecticide-treated bed nets (ITNs) especially by the most vulnerable groups, the children under 5 years of age and pregnant women; prevention and control of malaria in pregnant women by means of intermittent preventive treatment (IPT); and prompt response to malaria epidemic and emergency situations[2,8].

The objectives of this review are therefore to highlight the various aetiological factors of malaria, and suggest effective and multi-pronged approach to its prevention and control, in line with the strategies of the Roll Back Malaria initiative.

ENVIRONMENTAL FACTORS

Nigeria's geographical location and climatic conditions are favourable for the transmission of malaria. Malaria is seasonal with peak transmission between the months of June and October[10]. Malaria parasite, *P. falciparum*, requires the optimum temperature of between 20^0 and 30^0C to develop in the female *Anopheles* mosquito[11,12]. The parasite ceases to develop if the temperature is below 16^0C. Nigerian climate is conducive to the growth and development of malaria parasite. The threat of global warming can worsen the present situation of malaria in the tropical countries including Nigeria.

Prevailing local, often man-made, conditions in Nigeria tend to create environmental conditions favourable for the breeding of the vector and worsen the effects of the parasite on human populations. Deforestation increases man's contact with the vector, thereby contributing to the increase in prevalence of the infection. In the urban areas, the refuse management problem further aggravates the situation. Mosquitoes find breeding places in empty cans and containers, including the used, partially empty "pure" water satchets, littered indiscriminately in refuse dumps and other places. Urban malaria is aggravated by the generally poor environmental sanitation such as is provided by the blocked drains and sewers. The threat of global warming may also worsen the present situation of malaria in the country.

A relatively high atmospheric humidity of 60% prolongs the life cycle of the mosquito by making it more active and feeding more voraciously. Rain provides the opportunity for the breeding of mosquitoes. It also increases the atmospheric humidity necessary for the survival of the mosquito. However, heavy rain has the adverse effect of flushing out the breeding sites of mosquitoes, thereby interrupting the life cycle of the vector. *Anopheles* mosquitoes do not breed in altitudes above 2000 – 2500 metres, due to unfavourable climatic conditions. Man-made malaria may result from human undertakings that alter the environment and therefore provide breeding sites for the mosquitoes, such as irrigation projects, swimming pools, dams, etc. As these environmental changes are necessary for technological development, government, individuals and corporations and firms handling these projects should make concerted efforts, to observe protective measures that would reduce contact with the vectors of malaria.

Malaria has been observed to be more prevalent in areas of poor socio-economic development[13]. Housing condition plays an

important role in the epidemiology of malaria[9]. The ill-ventilated and ill-lighted houses are more likely to provide ideal resting places for the mosquitoes. Malaria is acquired in most instances by mosquito bites during the night and within dwelling places. Mosquito nets, if properly used and maintained, can provide a physical barrier to hungry mosquitoes[2]. If the nets are treated with insecticides, their effectiveness is greatly improved, generating a halo that extends beyond the mosquito net itself. Insecticide treated bed net, in addition to repelling and deterring mosquitoes from biting, also shorten their life span, thereby preventing them from transmitting the infection. Studies carried out in the last two decades showed that deaths in young children were reduced by an average of 20% as a result of use of insecticide treated bed nets[2]. However, barriers such as cost, especially among the poor, and the need to regularly re-treat the nets have caused problems with the use of insecticides treated bed nets[2]. There is a need to make ITNs affordable, widely available, and most importantly, appealing to the consumer. There is a need for social marketing schemes and health education campaigns to create the necessary public awareness. A lot of political commitment is necessary to achieve the goal of 60% of the people at risk of malaria sleeping under ITNs by 2005, in accordance with the Abuja Summit of April 2000. Some governments have gone ahead to reduce tariffs and taxes on mosquito nets, netting materials and insecticides, so as to lower retail prices. Local industries and private investors should also be encouraged to manufacture the necessary materials, instead of relying on importation alone.

HOST FACTORS

Certain host factors pertaining to genetics, immunity, nutrition and behavioural patterns of human beings have been found to affect the occurrence of malaria. The behavioural factors are influenced by cultural, ethnic and religious backgrounds. Males may be more frequently exposed to the risk of acquiring malaria than females when they lead a predominantly outdoor life. Furthermore, females in some Nigeria cultural settings use clothing that covers most of the body thereby creating less opportunity for mosquito bites than males. Malaria affects all ages but is uncommon in the very young. Infants born to immune mothers are partially protected from clinical malaria for a period of 4 to 6 months, as a result of passive immunity from the maternal IgG antibodies and the high levels of haemoglobin F[11,12]. The latter does not sustain parasitic growth as much as haemoglobin A. From about 6 months to 5 years, the child is susceptible to severe malaria attacks. In adult life, malaria is less likely to be severe and less frequent with low case fatality rates. This continues as long as the individual gets repeated antigenic stimulation.

Individuals with heterozygous AS haemoglobin (sickle-cell trait) have been noted to suffer from a milder illness with *P. falciparum* infection than those with the normal AA haemoglobin[14]. Haemoglobin S shields against malaria by crippling the red blood cells that malaria parasites need for survival. The abnormal haemoglobin distorts the red blood cells into a sickle shape, containing the malaria parasites, which are subsequently destroyed by the spleen. Haemoglobin AS genotype has been documented to reduce the risk of malaria by 73% while HbSS gives 67% protection against the infection[15]. However, the lethality of HbSS genotype offsets its protective effect. Although the mechanism of protection still remains a mystery, some researchers postulate that the abnormal protein in HbS gene may produce slight changes in the way the antigens are exposed on the surface of the red blood cells. Determining how the abnormal haemoglobin fends off malaria could lead to the development of vaccines and better treatments that safely mimic the mechanism of action involved.

It has been documented that HIV infection is significantly associated with the development of severe and complicated malaria[16]. Commonly reported complications of

malaria in persons also infected with HIV include anaemia, cerebral malaria, low blood pressure and renal failure. Increased susceptibility to and exacerbation of malaria with higher case fatality rates have also been noted when there are intercurrent diseases and other infectious conditions[11,14]. Presence of hypertriglyceridaemia has been reported as an indicator of the severity of *Falciparum* malaria[17]. Pregnancy increases the risk of malaria and primigravid women are at greatest risk[18,19]. This may result in abortion, premature labour or stillbirth. In areas of high malaria endemicity, the high maternal and infant morbidity and mortality associated with malaria in pregnancy results from anaemia in the mother and the presence of parasites in the placenta. This results in impairment of foetal nutrition and subsequent delivery of low birth weight babies with poor infant survival and development. In the last decade, more effective strategies for prevention and control of malaria in pregnancy have been developed and demonstrated to have a remarkable impact on improving the health of mothers and infants. These include the use of intermittent preventive treatment (IPT) of pregnant women with at least two doses of effective antimalarial drug during routine antenatal clinic visits. This approach has been demonstrated to be safe, inexpensive and highly effective in reducing the proportion of women with anaemia and placental malaria infection at delivery[13,18,20,21].

Malaria is predominantly a rural disease and is closely related to agricultural practices. It has also been found to be common in migrant workers, such as labourers involved with various engineering, irrigation, agricultural activities and among nomads[7]. Certain human habits and attitudes, such as sleeping outdoors, refusal to use insecticide-treated bed nets and other personal protective measures, have been found to influence man-mosquito contact. Other behavioural factors such as uncontrolled urbanization, subsistence agriculture, mining processes and population movements have contributed to the upsurge of malaria. Rural electrification has resulted to promotion of late-night outdoor - activities and has therefore increased biting opportunities for mosquitoes. Information, education and communication (IEC) packages are necessary to re-orientate the populace, especially those that are in positions of authority that can effect changes towards the prevention and control of malaria. These can be achieved by well planned and executed public enlightenment programmes that can create awareness of the various preventive measures of malaria, encourage and promote their implementation.

VECTOR FACTORS

Malaria vectors bite between dusk and dawn, and generally prefer well-oxygenated water rather than stagnant polluted ones to lay their eggs. It has been documented that a single infected female *Anopheles* mosquito with sporozoites in its salivary glands can infect several persons during its lifetime. In the absence of a vaccine, vector control is the only practical approach to malaria control. To be an effective vector, the female *Anopheles* mosquito must be present in sufficient numbers in and around dwelling places. The vector mosquito must also live for at least 10 to 12 days after an infective blood meal, to be able to transmit the infection. The strategy in malaria control is to shorten the life span of mosquito to less than 10 days by the use of insecticides[2].

Some mosquitoes prefer human blood (anthrophilic), others animal blood (zoophilic), while others show great variations in their feeding habits. Those that have greater preference for human blood are the most effective vectors of malaria. Most mosquitoes rest indoors on the walls after a blood meal (endophily) but others prefer to rest outdoors (exophily). Knowledge of resting habits is the basis for organising rational anti-mosquito measures[12]. In fact, the concept of malaria eradication is based on endophilism (indoor resting habits)[2,12]. Knowledge of both the breeding and biting habits of the mosquito is required for conducting effective anti-larval

operations necessary for controlling the vector. The term, vectorial-capacity, is used to describe the combined effect of the density of the vector population, its susceptibility to infection, life span and probability of feeding on man[12].

Vector resistance to some commonly used insecticides has been reported in some areas[2]. Alternative insecticides should be used if the mosquito is resistant to a given insecticide.

PARASITE FACTORS

Malaria is caused by the *Plasmodium* species; *P. falciparum, P. malariae, P. vivax* and *P. ovale*. *P. falciparum* is responsible for most infections in Nigeria and incidentally causes the greatest pathology[9]. It undergoes the highest multiplication and may infect up to 30% of the erythrocytes. Hosts of any age may be infected, but children are found more likely to harbour the infective gametocytes than the adults. For an individual to be a good reservoir of malaria, both sexes of the mature and viable parasites must be present in the blood in sufficient density to infect the vector mosquitoes.

Antimalarial drugs reduce the viability and infectivity of gametocytes to mosquitoes. However, anti-malarial drugs rapid lose their effectiveness when used as monotherapies. In some places, malaria parasites have been documented to be resistant to most affordable first line drugs[2]. The rate of emergence of drug resistance is increasing and few replacement drugs are being developed at affordable prices, as a result of the relatively limited profit potential for international pharmaceutical firms. The Roll Back Malaria global partnership is supporting countries to identity areas of drug resistance and to provide alternative drugs where appropriate. The spread of resistance may be better contained by the use of combination drugs with different biochemical targets in the malaria parasite. Artemisinin-based combination therapies (ACTs) have been shown to possess enormous potentials for enhancing clinical efficiency, in addition to delaying the emergence of resistant parasites[23]. However, such drugs are expensive, being more than 20 times the cost of chloroquine, the cheapest and most commonly used antimalarial drug. There is an urgent need for new and affordable antimalarial drugs, preferably with simplified treatment regimes that would encourage compliance. More than three-quarters of all malaria cases are first treated at home with antimalarial drugs purchased from chemist and patent medicine shops or the open market[2,9]. There is therefore a need to educate mothers, patent medicine dealers and other care givers on the correct and appropriate actions to take in treating malaria so as to limit the emergence and spread of resistant strains of *plasmodia*.

The malaria parasites may remain viable in blood stored at -4^0C, thereby constituting a problem in the choice of blood donors in malaria-endemic regions[10]. In view of this, it may be necessary to subject all prospective blood donors to compulsory blood tests for malaria parasite or the alternative procedure of administering anti-malarial drugs prior to blood donation should be considered.

CONCLUSION

This review shows that the problem of malaria cannot be tackled on one front because of the multiple and complex aetiological factors that are involved. Malaria poses a serious threat to the health and wealth of nations and individuals, being a disease of poverty and a cause of poverty. It has been shown to be a major constraint to economic development, widening the gap in prosperity between countries that have it and those that do not. Such a grave situation cannot be easily neglected. The best strategy for successfully combating the disease would be a collaborative effort involving all the sectors that have influence on its multifactorial aetiology. The cross-sectoral partnerships that are forming to deliver effective Roll Back Malaria interventions represent a new way of working that is essential to halving malaria deaths and suffering. If the multi-pronged measures to prevent and control the disease were concurrently applied, the opportunity for rolling back malaria amongst the

most severely affected populations would be feasible in the near future. Further research and development is needed to provide new tools, approaches and strategies as the malaria situation changes.

ACKNOWLEDGEMENTS

I sincerely appreciate the help given by my colleagues, Dr. Anne Ndu, Dr. B. S. C. Uzochukwu and Dr. Ngozi Nwosu, all of the Department of Community Medicine, University of Nigeria Enugu, who supplied me with some of the literature for the review.

REFERENCES

1. WHO Expert Committee on Malaria, 20th Report, World Health Organization. 1998, 3-10.
2. World Health Organization. The Africa malaria report. WHO/UNICEF, 2003, 13-23.
3. Murphy SC and Breman JG. Gaps in the childhood malaria burden in Africa: cerebral malaria, neurological sequelae, anaemia, respiratory distress, hypoglycaemia, and complications of pregnancy. American Journal of Tropical Medicine and Hygiene, 2001; 64: 57-67.
4. World Health Organization. World Health Report 2002. Reducing risks, promoting healthy life. WHO; Geneva 2002.
5. Steketee RW, Nahlen BL, Parise ME et al. The burden of malaria in pregnancy in malaria-endemic areas. American Journal of Tropical Medicine and Hygiene, 2001; 64: 28-35.
6. World Health Organization. Technical Report Series, 1984, No. 712.
7. Centers for Diseases Control. Transfusion-transmitted malaria. CDC, Division of Media Relations, April 2, 1999; (404): 639-641.
8. Federal Ministry of Health. Malaria control in Africa in the new millennium: working document prepared for the African Summit, Abuja, Nigeria, 25th April 2000, 17.
9. World Health Organization. African Summit on Roll Back Malaria, Abuja, Nigeria. WHO/CDS/RBM/2000, 17, Geneva, 2002.
10. Madaki AJK and Zoakah AI. The pattern of outpatient management of malaria in a Nigerian Teaching Hospital. The Nigerian Medical Practitioner, March/April 2002; 41: 27 – 30.
11. Lucas AO and Gilles HM. Short Textbook of Public Health Medicine for the Tropics, 3rd Ed. Arnold Publishers, London, 1998: 182-189.
12. Park K. Park's Textbook of Preventive and Social Medicine. 16th Ed., M/s Banarsidas Bhanot Publishers, Jabalpur, India, 2000, 189-199.
13. Parise ME, Ayisi JG, Nahlen BL, et al. Efficacy of sulfadoxine-pyrimethamine for prevention of placental malaria in an area of Kenya with a high prevalence of malaria and human immunodeficiency virus infection. American Journal of Tropical Medicine and Hygiene, 1998; 59 (5): 813-822.
14. Youmans GP, Paterson PY and Sommers HM. The biological and clinical basis of infectious diseases. 3rd Ed. Saunders, Philadelphia, 1985.
15. Crabb C. Haemoglobin variant gives strong protection against malaria. Bulletin of the World Health Organization, 2002; 80 (1): 78-79.
16. Chirenda J, Siziya S and Tshimanga M. Association of HIV infection with the development of severe and complicated malaria cases at a rural hospital in

Zimbabwe. Cent Afr J Med, 2000; 46 (1): 5-9.

17. Parola P, Gazin P, Patella F, et al. Hypertriglyceridemia as an indicator of the severity of *Falciparum* malaria in returned travelers: a clinical retrospective study. Parasitol Res, 2004; 92 (6): 464-6.

18. Schulman CE, Dorman EK. Intermittent sulphadoxine-pyrimethamine to prevent severe anaemia secondary to malaria in pregnancy: a randomized placebo-controlled trial. Lancet, 1999; 353: 632-636.

19. Okwa OO. The status of malaria among pregnant women: a study in Lagos, Nigeria. Afr J Reprod Health, 2003; 7 (3): 77-83.

20. Schultz LJ, Steketee RW, Macheso A, et al. The efficacy of antimalarial regimens containing sulfadoxine-pyrimethamine and/or chloroquine in preventing peripheral and placental *Plasmodium falciparum* among pregnant women in Malawi. American Journal of Tropical Medicine and Hygiene, 1994, 51 (5): 515-522.

21. van Eijk AM, Ayisi JG, ter Kuile FO, et al. Risk factors for malaria in pregnancy in an urban and peri-urban population in Western Kenya. Trans R Soc Trop Med Hyg, 2002 Nov-Dec; 96 (6): 586-92.

22. World Health Organization. Technical Report Series, 1986, 735.

23. World Health Organization. Antimalarial drug combination therapy: report of a WHO Technical Consultation, WHO/CDS/RBM/2001, 35. April 2001, Geneva.